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ABSTRACT

This syllabus gives detailed information on monitoring water quality for teachers and students. It tells how to select a sample site; how to measure physical characteristics such as temperature, turbidity, and stream velocity; how to measure chemical parameters such as alkalinity, dissolved oxygen levels, phosphate levels, and ammonia nitrogen levels; and how to sample plankton communities. In addition, it gives information on purchasing water quality analysis kits, data reporting, and constructing an environmental profile. (BB)

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UNDERSTANDING LOCAL ECOLOGY

Iowa-ASSIST
The University of Iowa

In Cooperation With Area Education Agencies
Supported By The National Science Foundation

SYLLABUS

FOR

MONITORING WATER QUALITY

SE 023 985

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INTRODUCTION

The Local Ecology Project will involve over three hundred teachers during the 1977-78 academic year in a consideration of local ecology as a means of increasing subject matter proficiency and as a model for involving students in such study. A major component of the program will be sharing information collected through common monitoring devises and procedures. This will provide broader understanding based upon a statewide sample as opposed to observation and interpretation of a single class effort in one local situation. The program is designed to provide an impact upon curriculum offerings, teaching strategies, and solutions to common environmental educational problems in schools.

Project Objectives

Specifically, the major objectives include the following:

a. to participate in a statewide effort for monitoring and interpreting variations and seasonal changes in local ecology.

b. to work cooperatively with other teachers in involving student groups in active projects for monitoring local ecological conditions.

c. to acquire skills in aquatic sample collection and analysis.

d. to interpret the data and thereby discover the dependence of life in an ecosystem on the physical and chemical parameters (characteristics) of that system.

e. to assist teachers with collecting and organizing information peculiar to Iowa and Iowa localities in the area of ecology.

f. to prepare a specific response to Public Law 257.25, Sections 3 and 4, which requires teachers to include the study of the local environment as a part of science instruction.

g. to develop a plan for continuing a statewide program for studying local ecology and comparing the data from the fifteen geographic areas of the State.

h. to formalize contacts with officials in the State involved with local and state programs for ecological monitoring (Soil Conservation, Department of Environmental Quality, State Hygienic Monitoring, Iowa River Project, etc.).

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SAMPLING SITE SELECTION

The sampling site(s) should be a river or stream which contains water throughout the year. The specific location should be a pool rather than a zone of rapid flow (riffle) to provide a mud bottom and a moderate rate of flow. Consideration should be given to location of the sampling site in relation to possible pollution sources. It may be desirable to locate sites above and below such sources.

Because numerous trips will be made to the site and class period time restrictions may be a factor, distance should be carefully considered when selecting a sampling site. Very often bridges over streams offer accessibility and desirable sampling sites.

Caution should also be exercised when determining the number of sites for sampling. Because of the repetitive nature of the sampling, a large number of sites could become a burden if sufficient student power is not available.

The instructor should make every effort to choose sites which are safe for student investigators. There should be room on the bank for making on site water quality determinations. Sites with deep holes or dropoffs should be avoided. More desirable sites will be those which are not used by the public for recreation.

If a river or stream is not available, a drainage ditch may be acceptable. Also, lakes, ponds, and quarry ponds make suitable alternatives. In addition, the standing water habitat is interesting to compare with the moving water habitat. In larger bodies of water a boat will be necessary to adequately sample, although sampling from a dock may be a desirable substitute if one is available.

Wells also furnish water whose quality is important for their users and might be of interest to student investigators. Chemical tests are of significance and examination for coliform bacteria is also important. However, because testing for coliform bacteria is expensive and technically demanding, it has not been considered as a water quality criterion for this study.

Frequency of Sampling

It is strongly suggested that samples be taken periodically throughout the year. For instance, the chemical and physical parameters might be obtained every other week, whereas the biological diversity index might be taken in the fall, winter, early spring, late spring, and summer.

I. PHYSICAL CHARACTERISTICS

A. TEMPERATURE

Temperature plays an important role in determining the species of organisms which can live in a particular body of water. It is also important because of the effect of the dissolved oxygen content of the water.

Stream Test

The Celsius water temperature should be determined at each testing site on each testing date. The temperature should be taken an arm's length from the shore, at a depth of at least 15 cm. to avoid measuring solar heated surface water. After allowing the thermometer to stabilize in the water for at least one minute, it should be read while in the water to prevent cooling by evaporation. Readings should be recorded to the nearest degree.

Pond Test

Thermoclines may develop in deep water during warm summer months. A thermocline is a layer of abrupt temperature change separating warm, less dense surface water from cold, more dense, deep water. Because of this, a bottom temperature reading may be useful. If the bottom temperature is significantly different from the top temperature, temperatures may be

taken at intermediate depths to determine the depth of the thermocline. These readings may be taken by lowering a dissolved oxygen sampler to the bottom or depth desired, filling it, and then taking the temperature of the water sample as soon as it is brought to the surface.

Equipment

Most schools will have a Celsius (centigrade) thermometer available, but if you need to purchase one, they are available from any science supply company for approximately three dollars. Other devices such as a fisherman's thermometer or a specially designed water testing thermometer could also be used if they are available, but the greatly increased cost compared to the small increase in accuracy and convenience may not justify the purchase of such equipment.

B. TRANSPARENCY (Turbidity)

The water transparency determines the depth of light penetration and gives an indication of the amount of suspended matter in the water. Transparency is measured with a Secchi disc, a round metal disc 20 cm. in diameter, with an attached rope or chain calibrated in metric units. The top of the disc is painted black and white in alternating quarters.

Test Procedures

To obtain a Secchi disc reading, lower the disc into the water, in the shade, if available, until it just disappears. The depth of the disc is read at the water surface using

calibrations on the rope or chain. Lower the disc a few centimeters and then raise it until it just reappears. Read the depth at the water surface again and average the two depth readings. This average is the Secchi disc reading. Several students could do the test independently and average their readings to give a more accurate result. If the Secchi disc reading is low (a few centimeters), the water contains much suspended mater. If, on the other hand, the reading is high (several meters), the water is quite clear and relatively free of suspended matter.

Equipment

Secchi discs may be purchased from many scientific supply houses. Prices of the discs range from twelve to fifteen dollars. A Secchi disc can be made for approximately $1.50. The critical points in the construction are the diameter, which must be 20 cm. and the paint, which must be water resistant. Construct the disc as shown in figures 1 and 2.

Salvage yards may have available discs of the above dimension; however, if one of the exact diameter is not available, a smaller diameter disc may suffice as a weight, with a masonite disc of the precise measurement above it. An eyebolt is secured in the middle of the weight and disc, to which a rope or chain is attached. The rope or chain should be calibrated in ten centimeter intervals beginning at the level of the disc by marking with paint or hog rings.

Secchi Disc

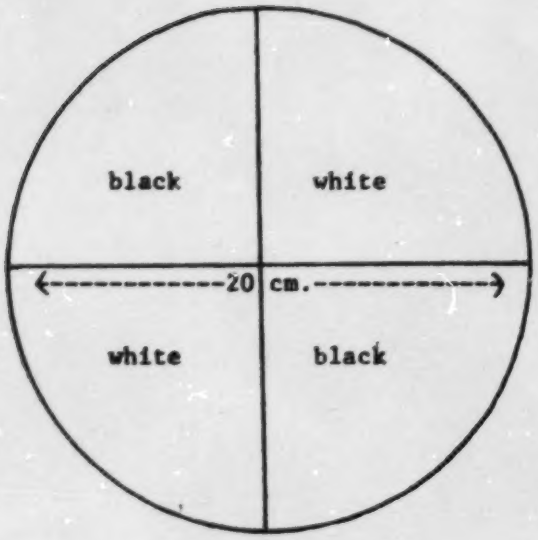


Figure 1

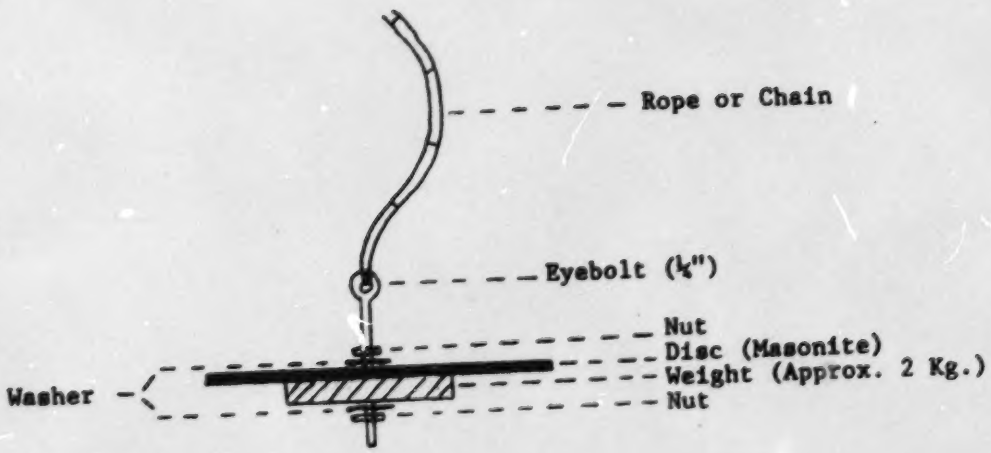


Figure 2

C. VELOCITY

The stream's velocity should be measured at each sampling site as this measurement influences factors such as dissolved oxygen and carbon dioxide concentrations. If a cross sectional profile is also made, the volume rate of flow of the stream can be calculated.

The accepted method is to float an orange, or any other object which has a density slightly less than water, in the stream and measure the travel time between two points and is recorded as meters/second. The object used must be nearly submerged in the stream so the wind does not affect the motion. Also, the object must be free floating with the stream. This test may be difficult to conduct in the winter.

To make the distance measurement as accurate as possible, pairs of stakes on parallel lines should be set up on the bank as shown in figures 3 and 4. Two observers can then measure the time it takes for the object to float the distance "d." The orange should be placed at a position somewhat upstream from the first observer's line so the orange will reach the rate of flow of the stream by the time it passes the first observer. Also, the orange should be placed in that part of the stream where the rate of flow seems greatest.

Care should be taken to be sure the orange moves nearly perpendicular to the two parallel sight lines. It may be necessary to try the experiment at several locations along the stream in order to get the orange to follow a perpendicular

path. The experimenter should also try to obtain his data in a location shielded from the wind.

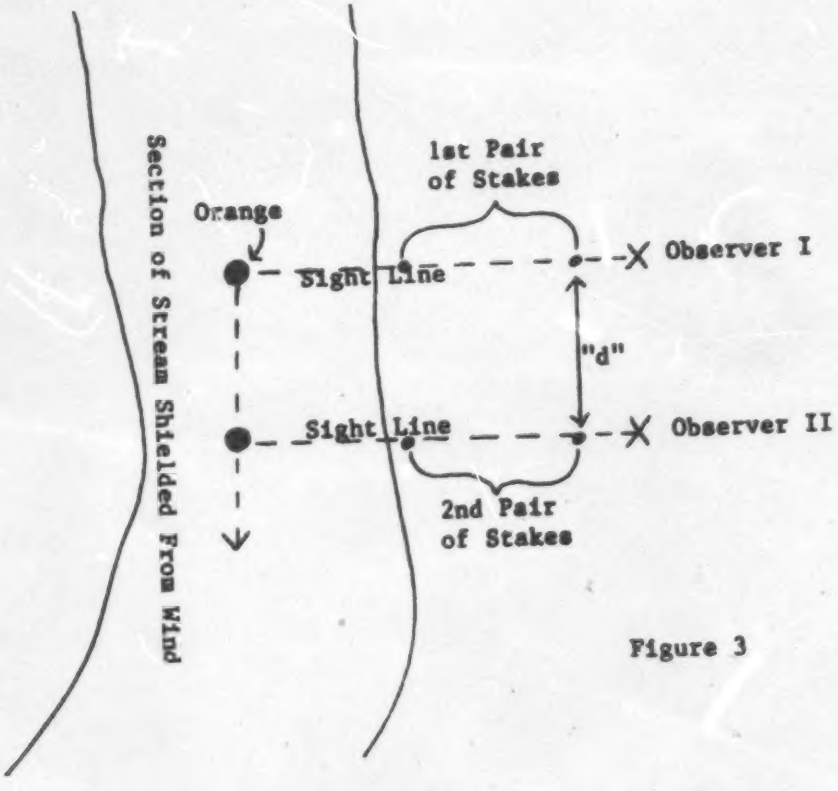


Figure 3

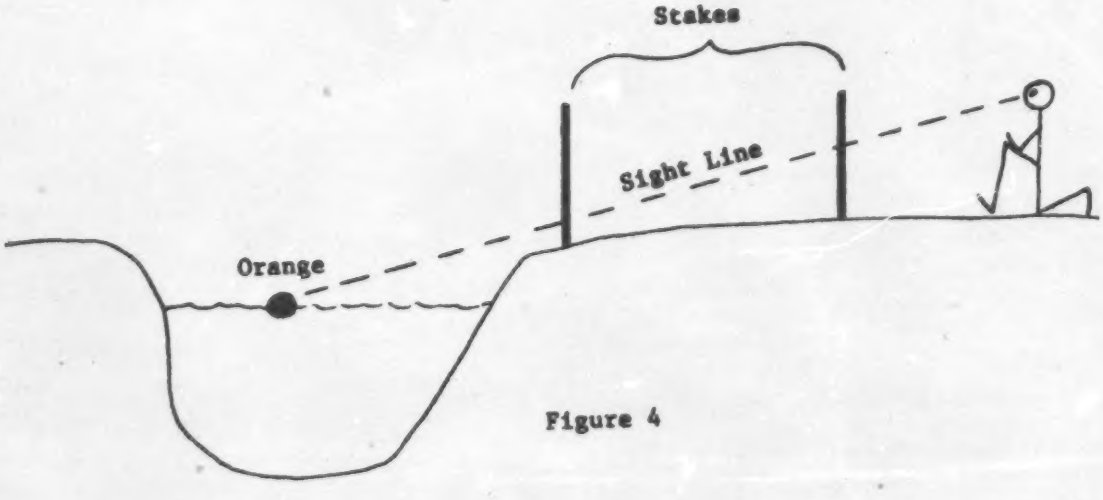


Figure 4

Depth

The depth of the sampling site should also be found. This may be obtained by using the Secchi disc. Lower the disc into the water until the rope becomes slack. Pull up on the rope until it becomes taut, mark the rope at the water surface, and measure the depth.

Flow

Because the volume of flow is difficult to measure without elaborate equipment, rate the flow as:

1) Flood
2) Bank Full
3) Average
4) Low
5) Very Low

II. CHEMICAL PARAMETERS

The chemical parameters are unique for each environment. Numerous tests can be used to determine the concentrations of the substance to be measured. Most of these tests are associated with two basic laboratory techniques, titration and colorimetry. Field kits have been developed using these techniques in simple, easy to use forms. With the use of these types of kits, the following chemical parameters were selected for study: alkalinity, dissolved oxygen, ammonia, nitrate, and phospate. The dissolved oxygen test must be done in the field where the sample is taken. The remainder of these tests can also be done in the field but may be done on samples brought back to the laboratory. The results of these tests are normally expressed in parts per million (ppm). Two common conversions needed are one part per million is equal to one milligram per liter (1 ppm = 1 mg/l) and one grain per gallon equals 17.1 parts per million (1 gpg = 17.1 ppm). The kits listed are produced by the Hach Chemical Company and are available from Iowa-ASSIST (USE), University of Iowa.

A. ALKALINITY TEST

Alkalinity is related to the buffering systems in water. Buffers are systems that tend to moderate changes in pH. Alkalinity refers to the capability of water to neutralize acids and stabilize the pH of the water. Conditions found in natural waters involve a complex of the carbon dioxide-carbonate-bicarbonate system. Alkalinity most commonly occurs when carbonates, bicarbonates and hydroxides of calcium, magnesium, and sodium metals are present.

The levels and types of alkalinity depend directly on the source of the water. Natural surface and well waters usually contain less alkalinity than sewage or wastewater samples.

High levels of alkalinity may indicate that strongly alkaline industrial waste is present. Alkalinity in natural unpolluted water ranges from 50-300 ppm. In nutrient-rich bodies of water, sewage lagoons, etc., it may range as high as 500 ppm.

Hach Model AL-36B Test Kit or Hach Alkalinity Test Kit Model AL-AP may be used for this test. Model AL-AP is for alkalinity only and is the same test that is contained in the larger Model AL-36B Test Kit. The result of this test is given in grains per gallon as calcium carbonate.

B. DISSOLVED OXYGEN TEST

Dissolved oxygen (D.O.) in water is a result of two processes. D.O. occurs in water as a result of green plants carrying on photosynthesis and from diffusion from the air.

The concentration of D.O. in water will be limited by temperature and light. As the temperature of the water increases, the solubility of oxygen decreases; therefore, warm water contains less oxygen. Another limiting factor will be the depth of the water. D.O. is in lesser concentration the further from the surface.

D.O. concentration maximums are 15 ppm in fresh water. Most fish can exist in D.O. concentrations as low as 4 ppm and can exist comfortably at a 6-8 ppm concentration. Other aquatic life may exist comfortably at much lower concentrations.

D.O. tests may be done by means of a surface sample in shallow water. In depths of 3 meters or more a bottom sample

should be taken to determine the variation in D.O. content. In taking a D.O. sample it is very important that the atmospheric oxygen has a minimum surface area contact with the water sample. If bubbling occurs while sampling, additional oxygen will dissolve and not provide an accurate test. In this case, the sample should be discarded and a new sample collected. A surface D.O. sampler is illustrated in figure 5. Figure 6 illustrates a "home-made" device for collecting water samples below the surface.

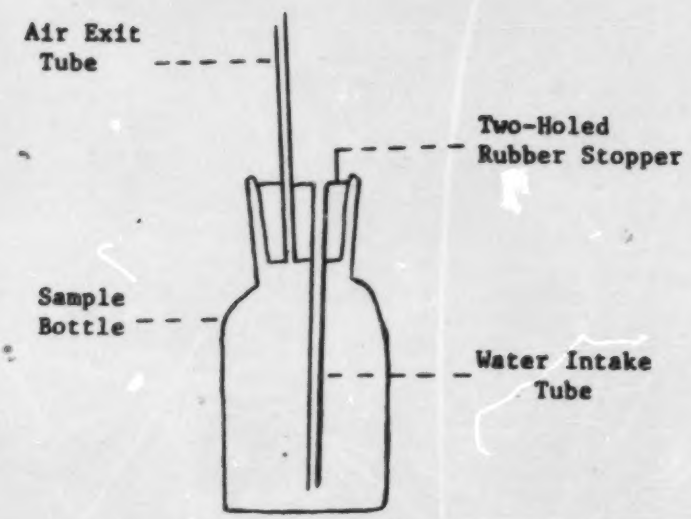


Figure 5

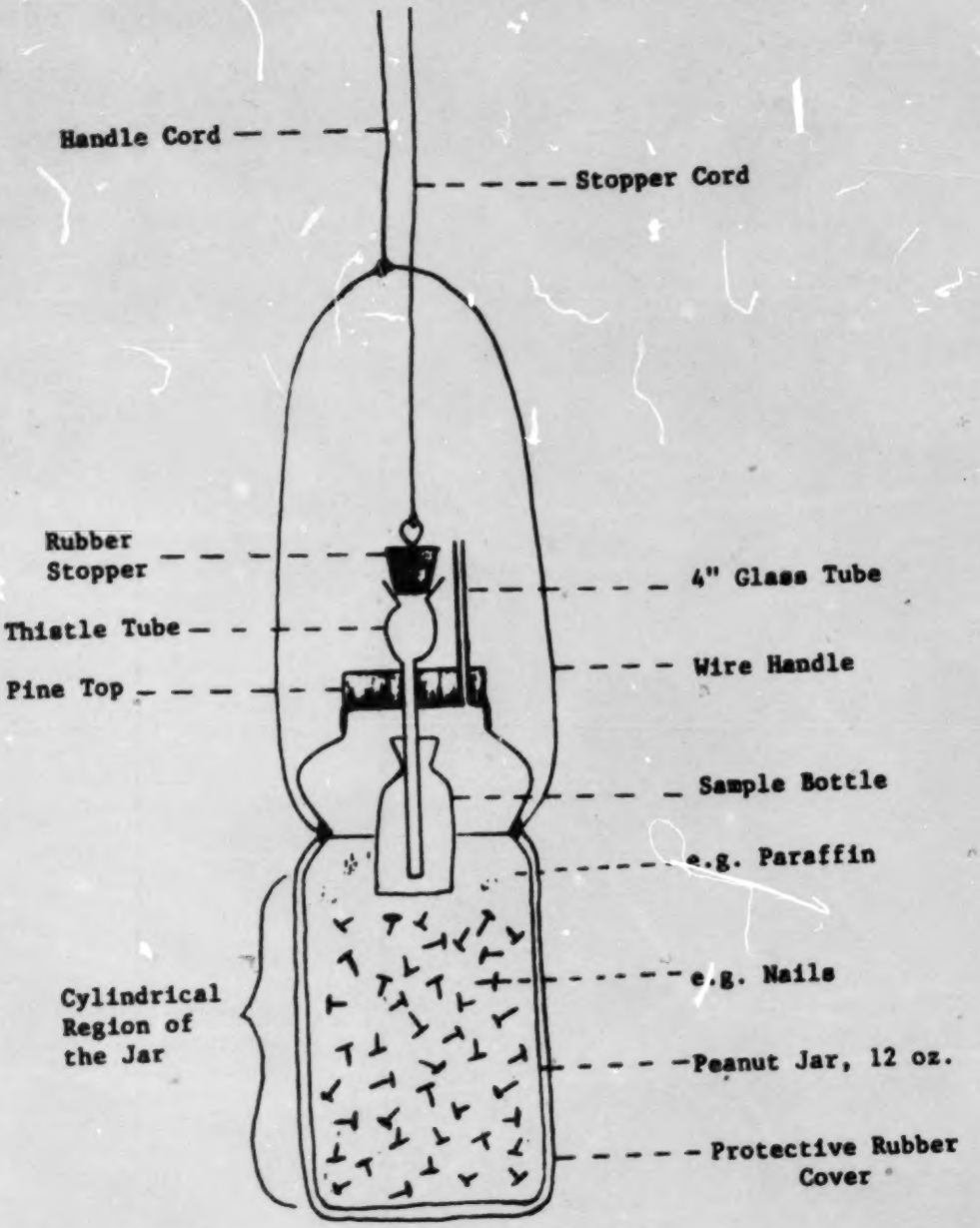

Handle Cord
Stopper Cord
Rubber Stopper
4" Glass Tube
Thistle Tube
Wire Handle
Pine Top
Sample Bottle
e.g. Paraffin
e.g. Nails
Cylindrical Region of the Jar
Peanut Jar, 12 oz.
Protective Rubber Cover

Figure 6

Method of collecting the D.O. sample:

1. Insert the stopper apparatus into the sample bottle.
2. Hold a finger over the water intake tube until the bottle is held vertically at the depth the sample is to be taken.
3. Remove finger and allow the bottle to fill with water.

Method of collecting a D.O. bottom sample:

1. Using the cord attached to the handle of the sampler, lower the sampler to the bottom of your water source.
2. Using the cord attached to the stopper, pull it from the thistle tube, allow approximately one minute and fifteen seconds (or until the bubbles stop coming up) for the sample bottle to fill.
3. Pull the sampler to the top with the cord attached to the handle, unscrew the lid of the sampler and remove the sample bottle containing your water sample.

Commercial kits containing the materials for fixation, acidification, and titration, may be purchased with or without a water sampler device. The Hach Kit Model OX-10 contains the sampler, while the Model OX-2P is without the sampler. Both Kit Models OX-10 and OX-2P contain all necessary chemicals and glassware for carrying out the D.O. test.

The fixation phase of the test should be done immediately by adding powder pillows I and II. The addition of powder pillow III and the titration may be completed in the laboratory. The completion of the test, titration, should be done within forty-five minutes after adding powder pillow III. A few drops

of a weak starch solution may be added to give the sample a deep blue color. This will produce a more definite color change as you reach the end point. The D.O. concentration is measured in parts per million (ppm). Care should be taken to keep the PAO in the dark since PAO breaks down when exposed to sunlight.

C. PHOSPHATE TEST

Phosphates ($PO_4^{\equiv}$), though essential for the growth of all living things, will upset aquatic environments if present in excess amounts. Agricultural, domestic, and industrial wastes increase the phosphate concentration resulting in an algal bloom which is not only a nuisance to recreation, but eventually causes a decrease in the dissolved oxygen content. With oxygen no longer available to other organisms, the local biotic community is upset.

Phosphate content ranges from 0.01 to 0.05 ppm in most natural waters. Waste water can have a range of 5 to 30 ppm.

The Hach Phosphate Test Cube Kit contains a powder pillow reagent and a cube with color standards attached. Measurements are made by comparing the color of the sample after the reagent is added to the standard color cubes (colorimetric). The range is from 1 to 5 ppm and is calibrated to the nearest ppm. The 5 ml sample test takes five minutes. The test is quick, simple, inexpensive, and can be performed in the field. Inconsistencies in this test can be caused by large amounts of turbidity. Also, arsenate and hydrogen sulfide will interfere with the test.

Greater precision can be obtained with other commercial test kits, but with considerably more expense.

D. NITRATE-NITROGEN TEST

Nitrates (NO_3^-) are often found in water. Sources of these nitrates may be man-made fertilizers, biological wastes, or atmospheric nitrogen that has been converted to nitrates by lightning or fixed by bacteria on legume plants.

Large amounts of nitrates in water supplies can cause methemoglobinemia (blue babies). A limit of 10 ppm nitrate (N) has been set for public water supplies.(1) A 10 ppm nitrate (N) is equivalent to 45 ppm nitrate (NO_3^-).

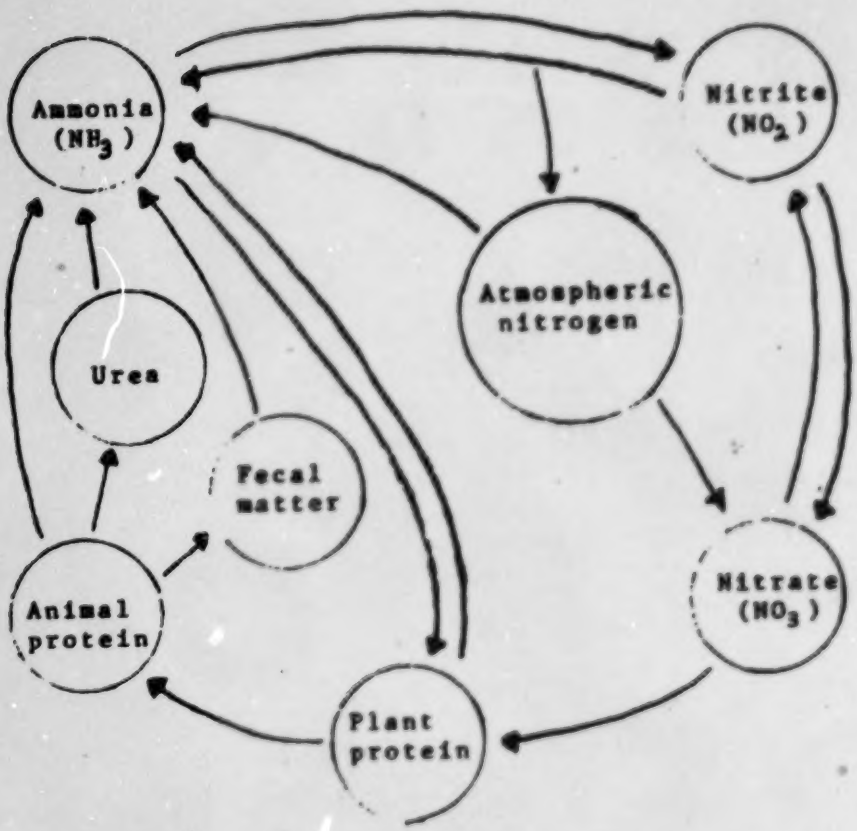
The small Hach Nitrate Test Cube Kit gives quick colorimetric results. It should give readings within 5 ppm to 10 ppm depending upon the ability to compare the colored sample. The Model Ni-14 Nitrate Test Kit gives readings using a color disc marked for each ppm which should allow reading it to the nearest 3 to 5 ppm, again, depending upon the ability to compare color. More accurate readings may be obtained using the Hach DR-EL Colorimeter.

E. AMMONIA NITROGEN TEST

Ammonia (NH_3) is a natural chemical decomposition product of plant and animal protein decay. It is commonly used in commercial fertilizers and is a recyclable substance that can be used to directly produce plant protein.

The presence of ammonia nitrogen in raw surface water usually indicates domestic pollution. However, ground waters often contain

ammonia nitrogen due to natural microbial reduction processes. A presence of ammonia nitrogen of 0.5 ppm is considered the maximum tolerable limit with less than 0.01 ppm as being desirable (National Technical Advisory Committee on Water Criteria to the Secretary of Interior, 1968).



Nitrogen Cycle

Testing for Ammonia Nitrogen

Testing for small quantities of ammonia nitrogen in water samples can be easily achieved by using the Hach Ammonia Nitrogen Test Kit. Utilizing the Nesslerization Method, the test measures from 0.5 to 2.5 ppm of ammonium nitrogen. Ammonia (NH_3) ppm can be determined by multiplying results by a factor of 1.21 and multiplying by 1.29 gives the ammonium ion (NH_4^+) ppm.

The Hach Cube Kit for the ammonia nitrogen test is a pocket-sized plastic case containing Nessler's Reagent in a dispensing bottle, a test tube-color comparison cube combination, and simple directions.

Special conditions and considerations affecting the test include:

1. Temperatures above and below 20°C. Temperatures above 20°C. give high results, those below give low results.

2. Water hardness greater than 100 ppm (6 grains). Hardness can be reduced by adding one drop of Rochelle Salt Reagent.

3. If Nessler's Reagent becomes brown, discard; however, a slight precipitate is normal. For preparation of large quantities or fresh solutions of Nessler's Reagent---a potassium iodide, mercury II chloride, and sodium hydroxide solution---consult the Special Solutions and Reagents section of the CRC Handbook of Chemistry and Physics.

4. If iron, sulfide, and industrial organic contaminants interfere by causing turbidity, the sample may have to be distilled.

III. BIOLOGICAL PARAMETERS

Diversity Index

The diversity index is a measure of the variety of species and their abundance in a particular habitat. Generally, habitats with considerable variation in environmental conditions and/or with unfavorable conditions for living organisms support a community low in numbers of species with high populations per species. Where the environment has less variation and where conditions are ideal, there is likely to be a larger number of species but with low populations per species. The diversity index thus gives an indication of the stability and quality of the sampling site although cause and effect relationships between diversity and stability are obscure.

Simpson's diversity index (DI) for a habitat is obtained by dividing the square of the total number of organisms counted, by the sum of the square of numbers of organisms in each species.

$$* \quad DI = \frac{N^2}{\Sigma(n^2)}$$

Where N = total number of organisms counted and n = number of individuals per species.

Counting a large number of individuals will provide a closer approximation of the diversity present.

*For statistical example, see page 32.
For specific reference regarding the DI, see Kaill & Frey, 1973 or Wilhm & Dorris, 1968.

The diversity index in an aquatic environment varies from 1, when only one species is present, to 3-4 or more in extremely species rich habitats.

A. SAMPLING A BENTHIC COMMUNITY

Benthos refers to the bottom of the aquatic environment. A benthic organism occupies the bottom of such an environment.

The determination of analysis of community structure of benthic organisms is one of the best measures, at present, of the long term effects of change in an aquatic environment. The diversity index is the most appropriate parameter to use in analyzing the structure of a community.

Once the site has been determined, an apparatus must be used to secure the benthic sample. Commercial apparatus such as the Ekman dredge or the Surber sampler are commonly used, however, due to the cost it may be prohibitive for some schools. An inexpensive sampler may be easily constructed from readily available materials. Illustrations of three "homemade" samplers are shown in figures 7, 8, and 9.

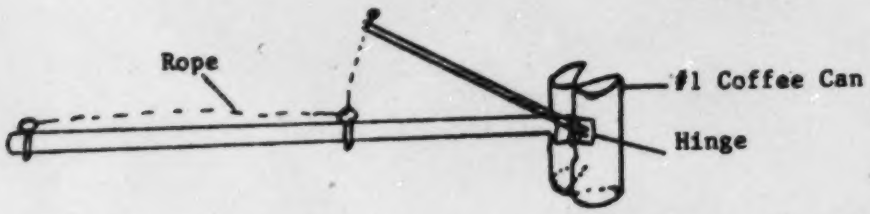


Figure 7

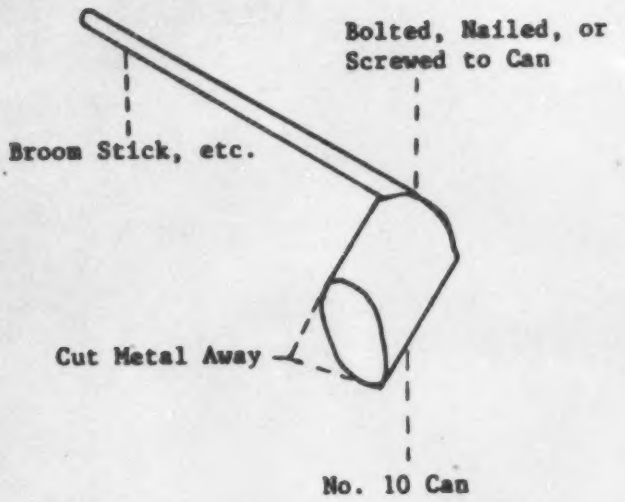


Figure 8

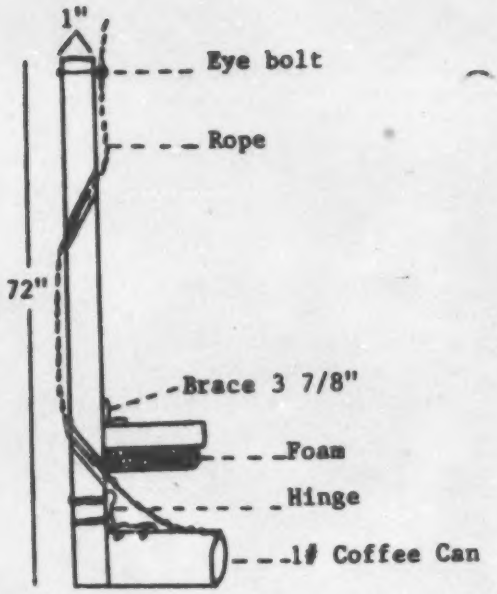


Figure 9

The sampling technique may vary slightly according to the sampler used, but should be consistent for each sampling site.

Materials Needed for Field Sampling

Bottom sampler
Collecting jars (i.e. baby food jars)
White, flat pan
Forceps
Sieves (10 mesh and 30 mesh)
Five-gallon plastic pails (2)

Materials Needed for Laboratory

Eye droppers
Shallow dishes (Petri dish)
Sugar solution (275 g/l)
Dissecting scope

Field Sampling Steps

1. Lower sampler into water and secure the sample.

2. Pull the sample to the surface but not above the surface of the water. The transfer bucket should be tipped sideways toward the sampler and at the same time the sampler should be lifted into the bucket. Empty the entire sample into the bucket.

3. To dilute, pour water from the stream into the bucket with the sample.

4. Whirl the sample while pouring through the sieve held at the water surface. Do not pour sand, gravel, or small stones into the sieve. Check the sieves after each dilution for organisms. Remove with forceps and place in a collecting jar. Dump the remaining debris from sieves into the white, flat pan.

5. Repeat steps 3 and 4 until diluted water is almost clear.

6. Dump remaining sand, gravel, or small stones from the bucket into the pan. Clean sieves by pouring water back through the mesh into the pan. Return to the laboratory for observation.

Laboratory Observation

1. Add sugar solution to the white pan until the sample is covered by a one half inch of solution.

2. The organisms will float to the surface. Remove with forceps and eye droppers to shallow dishes (petri dishes) for further examination.

3. After visible organisms have been removed, stir the mixture and repeat step 2. This should be repeated at least six times.

4. Using a dissecting scope, separate, count, and record the different kinds of organisms in the shallow dishes and field site collecting jars. It is not necessary to classify the organisms. Specimens may be preserved for continuing study.

5. Using the diversity index formula given on page 23, compute the diversity index for the sample.

Discussion

Most benthic studies involve area measurements (i.e. individuals/square meter). This study involves volume sampling. Consistent sampling technique should give reliable diversity indices. The following data compares the Ekman dredge to the sampler in figure 9.

Diversity Index

	Sample 1	Sample 2	Sample 3
Ekman dredge	3.27	2.71	1.89
Sampler (fig. 9)	--	2.83	1.69

Trial sampling suggests a close relationship between results obtained using commercial dredges and "homemade" apparatus. The field trials with "homemade" apparatus samples volume rather than area. A standard volume (approximately 475cc or a 1 lb. coffee can) should be established to insure sampling uniformity.

The following suggestions may facilitate the collecting and analyzing of the benthic community. When using sampler (fig. 9), grasp and hold rope tightly when bringing the sampler to the surface. Whirling the bucket (field step #4) is important to keep silt and organisms in suspension. Field testing suggests the use of two sieves with the top sieve (10 mesh) and the bottom sieve (30 mesh) agitated in the water to help move the silt through the mesh and speed the screening. The end point (field step #5) may be difficult to reach in a muddy stream. Dissolve (lab step #1) 275 grams of sugar in one liter of hot water. Lab step #3 should be repeated until no organisms are visible after several mixings.

Taxonomic determinations (lab step #4) of benthic organisms are not necessary for species diversity (DI) analysis. However, this might be used as a supplementary activity. The specimens can be preserved in 4% formalin solution.

Equipment Costs (Approximate)

Ekman dredge	$50 - $270
Sieve set	$10 - $15
Surber dredge	$85+
Sampler (figure 7)	$2
Sampler (figure 8)	Free materials
Sampler (figure 9)	$4
White enamel pan	$6
Five-gallon plastic pail	Free (contact custodian)

Remaining materials are usually found in most laboratories.

The following references are good for benthic studies:

(1) Kaill and Frey, 1973.

(2) Needham and Needham, 1970.

(10) Pennak, 1953.

(3) Reid, 1967.

(12) Ward and Whipple, 1959.

(13) Wilhm and Dorris, 1968.

B. PLANKTON COMMUNITIES

Plankton are found in all aquatic ecosystems except for fast moving rivers. Plankton are microscopic plants and animals whose powers of self-locomotion are so limited that they cannot overcome currents. Their distribution, therefore, is controlled largely by the currents in their ecosystems. Most can move a bit, however, either to control their vertical distribution or to seize prey.

The planktonic community responds quickly to changes in environmental conditions. Usually changes which stress the plankton decrease the diversity index by eliminating certain species, lowering the populations of others, and favoring a few species whose population increase greatly. Therefore, the diversity index is a valuable tool in assessing water quality.

Phytoplankton (plant plankton)

Phytoplankton are microscopic plants that are the main producers in most aquatic ecosystems.

Diatoms (Golden Algae) are minute, single-celled organisms which have cell walls made of silica. Brown and yellow pigments are more abundant than chlorophyll in diatoms. Each cell is composed of two halves that overlap and occur as single cells, in pairs, or in colonies. They may be free-floating or attached to rocks and aquatic plants.

Blue-green Algae are very simple and lack a nucleus. The chlorophyll is not concentrated in chloroplasts as it is in higher plants. Certain members of this group are often responsible for the so-called "algal blooms" in nutrient-rich waters. They may give the water an appearance of pea soup and produce unpleasant smell and taste. When the algae die, the oxygen depletion resulting from bacterial growth may kill fish and further upset the ecosystem.

Green Algae have organized nuclei and their chlorophyll is confined to chloroplasts. They occur as single cells or in colonies. Chlorella or Spirogyra are representatives of Green Algae that respond well in nutrient-rich water. Two flagellates, Euglena and Chlamydomonas are very common in bodies of water that are rich in organic matter.

Zooplankton (animal plankton)

Zooplankton are microscopic and near microscopic animals that play key roles in most aquatic food chains. Some feed on dead organic matter while others feed on algae, bacteria, and on smaller zooplankton. Zooplankton, in turn, become food for higher order consumers such as mayfly nymphs and caddisfly larvae. .

Protozoans are microscopic, single-celled organisms that are by far the most abundant zooplankton in water. Locomotion is by means of flagella, cilia, or pseudopodia.

Rotifers are multicellular small unsegmented animals often mistaken for single-celled organisms. Many species have cilia that appear to rotate like wheels to sweep food into their mouths. They feed on protozoa and algae and are a major part of the zooplankton.

Crustaceans are arthropods and generally larger than rotifers. Some crustaceans eat rotifers; others eat algae, bacteria, and protozoans; still others feed on dead organic matter. Most require fairly high oxygen concentrations. Daphnia (water flea) is the most common member of a group of crustaceans called Cladocerans. Cypridopsis is a common member of a group of crustaceans called Ostracods or seed shrimp. These are found just above the bottom of ponds where they feed on bacteria and algae. They can tolerate fairly low D.O. levels. The final group of crustaceans is the Copepods. Cyclops, a common copepod, may indicate water rich in nutrients if it is present in unusually high numbers.

Laboratory Technique

Materials Needed:

Plankton net with collecting bottle
Plastic pail or suitable container with 4 liter mark
Erlenmeyer flask (250 ML) with cork or a baby food jar and lid
Standard eyedroppers (2)
Slides and coverslips (5)
Compound Microscope
4% Formalin Preservative (with 5 drops glycerine/50 ml solution added)
Resource books and keys

Procedure:

1. At the collection site using the plastic pail, collect a sample of water being careful not to disturb the bottom of the pond or stream. Pour the contents of the pail through the plankton net to filter out plankton into the collecting bottle. If the water is deep enough, the plankton net may be repeatedly tossed out into the stream and retrieved or towed behind a boat until sufficient plankton has been collected. Next, pour the contents of this bottle into the flask or baby food jar to be transported back to the laboratory.

2. In the laboratory, using an eyedropper, place on each of five slides 1 drop of the sample collected. With another dropper also place on each of the same five slides 1 drop of the Formalin preservative. Place a covership on each of the five slides.

3. Adjust the compound microscope for total magnification of 100X (10X eyepiece and 10X objective). Place the slide on the stage of the microscope and count the number of each type of organism seen in a randomly picked field of view. Record the results and repeat this same procedure with the remaining four slides. Using the summation of these five slide views, the diversity index can then be calculated. Higher magnification could be used with high populations in the sample.

Notes on Plankton Sampling

The following example can be used as a guide for the procedure described.

ON SLIDE # 1 A total of 34 organisms were found that belonged to five different types. They were:

3 of type "X"	TOTAL ORGANISMS = 34	
1 of type "Y"		
2 of type "A"	N^2 or $(34)^2$ = 1156	D.I. = 1.55
27 of type "B"		
1 of type "C"	Σn^2 = 744	
34		

ON SLIDE # 2 A total of 20 organisms of five types were found.

2 of type "X"	TOTAL ORGANISMS = 20	
1 of type "Y"		
1 of type "A"	N^2 or $(20)^2$ = 400	D.I. = 1.72
15 of type "B"		
1 of type "D"	Σn^2 = 232	
20		

ON SLIDE # 3 A total of 31 organisms of four types were found.

1 of type "X"	TOTAL ORGANISMS = 31	
2 of type "Y"		
2 of type "A"	N^2 or $(31)^2$ = 961	D.I. = 1.40
26 of type "B"		
31	Σn^2 = 685	

ON SLIDE # 4 A total of 22 organisms of four types were found.

2 of type "X"	TOTAL ORGANISMS = 22	
1 of type "Y"		
2 of type "A"	N^2 or $(22)^2$ = 484	D.I. = 1.62
17 of type "B"		
22	Σn^2 = 298	

ON SLIDE # 5 A total of 22 organisms of five types were found.

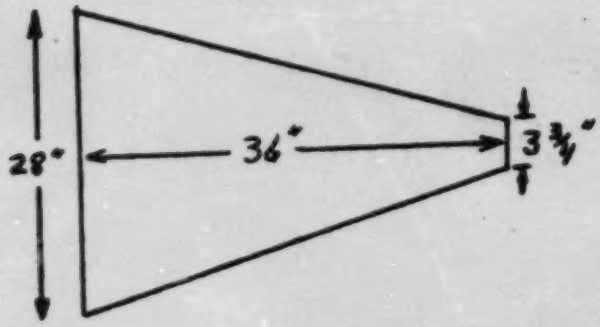
3 of type "X"	TOTAL ORGANISMS = 22	
1 of type "Y"		
2 of type "A"	N^2 or $(22)^2$ = 484	D.I. = 2.01
15 of type "B"		
1 of type "C"	Σn^2 = 240	8.3
22		

D.I. = 5 $\overline{)8.3}$ = 1.66

An average for the five slides would be arrived at by adding the five diversity indices for a total of 8.3 and then dividing by 5 to get a final answer of 1.66 for the diversity index.

Discussion on the Plankton Net Used

Although plankton nets are commercially available, the materials to construct a satisfactory one are inexpensive and the construction fairly easy. The cloth used is from a cotton bed-sheet or pillow case. The dimensions and pattern are shown below:



The narrowest opening should have a one-half inch hem sewn along its edge. A one-quarter inch seam is sewn along the edge of the cloth to connect the two longest sides forming a cone or funnel of cloth. A two inch casing is then sewn along the widest opening leaving a place to insert the wire. Turn the cloth inside out. The wire used is steel clothesline wire, to prevent rusting, that has been formed into a loop that is approximately ten inches in diameter. This, when inserted into the cloth casing, will be compressed into a circle of approximately eight and one-half inches and will provide pressure to keep the large end of the net open and will also act as a place for attachment of chains if the net is to be drawn through the water. A small link chain can be attached to the wire at three points that are 120 degrees from each other. The chain used may be of the type that is used for hanging flower pots. To keep the chain from tangling and twisting, a fairly large fishing swivel can be attached to the free ends of the three chains followed by a small nylon rope of whatever length one desires.

On the end with the narrow opening, a bottle will be attached. The bottle used is a Duraglass medicine bottle of 80cc volume. The cap should have its top drilled out so that the opening is the same size as the inside diameter of the cap being careful not to damage the threads. The cap should just fit inside of the narrow opening of the net and is permanently attached with a heater hose clamp of the type used on cars.

A fairly satisfactory net for larger plankton can be made by attaching the upper part of a lady's stocking to a hoop of proper size. Then cut off the foot and tie or attach to a bottle as previously described.

The following references are good for planktonic studies:

(6) Andrews and Moore, 197[illegible].

(7) Eddy and Hodson, 1967.

(2) Needham and Needham, 1970).

(10) Pennak, 1953.

(3) Reid, 1967).

(11) Stoker, 1972).

A Few Thoughts Concerning Public Relations

People walking along river banks and into rivers with flasks, nets, and other equipment attract a certain amount of attention. When the community discovers that water quality is one of the topics of study, many questions are asked. How dirty is the river? Who is polluting the river and what are you going to do about it? When questions such as these are asked of project participants, both students and teachers, it becomes important to explain that the project is not related to studies run by agencies such as the Department of Environmental Quality (DEQ) or the Environmental Protection Agency (EPA). The project centers on the techniques of quality measurement and how these relate to ecological principles rather than to the development of a comprehensive study on the basis of which recommendations for environmental control might be made.

For example, during the project students may notice a sharp increase in the nitrate level at a particular testing site. This increase could, if it persists for a significant interval of time, cause an increase in the algal and bacterial population and a decrease in the fish population, indicating a higher level of pollution. However, the opportunity for teacher-student scientific investigation and the study of the interrelationships between the parameters investigated are central to the project with the actual pollution levels as obtained in the project serving as interesting awareness inducing sidelights.

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1. Kaill, Michael W. and Frey, John K. Environments in Profile: An Aquatic Perspective, Canfield Press, San Francisco, California, 1973.

   This book provides a basic ecological background. In addition, it discusses the significance and measurement of various aquatic parameters. An analytic approach is described using an environmental profile.

2. Needham, James G. and Needham, Paul R. A Guide to the Study of Fresh-Water Biology, Holden-Day, Inc., San Francisco, California, 1970.

   This small, well-illustrated paperback will facilitate the recognition of fresh-water organisms both in the field and laboratory. Considerable attention is provided in identifying algae, invertebrates, and fishes. Also, methods of sampling and analyzing aquatic organisms and their environments is included.

3. Reid, George K. Pond Life, A Golden Nature Guide, Golden Press, Western Publishing Co., Racine, Wisconsin, 1967.

   This small inexpensive paperback illustrates quite well the more abundant aquatic organisms.

The additional selected bibliography may prove to be useful for both teacher and students.

4. APHA, AWWA and APCF. 1961. Standard methods for the examination of water and wastewater. American Public Health Association, Inc., 1790 Broadway, New York.

5. Andrews, William A., Ed. Contours: Studies of the Environment, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1972.

6. Andrews, William A., Moore, Donna K., and Le Roy, Alex C., A Guide to the Study of Environmental Pollution, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1972.

7. Eddy, Samuel and Hodson, A. C. Taxonomic Keys to the Common Animals of the North Central States, Burgess Publishing Co., Minneapolis, Minnesota, 1967.

8. McCaull, Julian and Crossland, Janice Water Pollution, Environmental Issues Series-Scientists' Institute for Public Information, Harcourt Brace Jovanovich, Inc., New York, New York, 1971.

9. Odum, Eugene P. Fundamentals of Ecology, W. B. Saunders Co., Philadelphia, Pennsylvania, 1971.

10. Pennak, Robert W. Fresh-Water Invertebrates of the United States, Ronald Press Co., New York, New York, 1953.

11. Stoker, Danial G., Agsteribbe, Marcel, Windsor, Nancy R., and Andrews, William A. A Guide to the Study of Fresh-Water Ecology, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1972.

12. Ward, Henry B. and Whipple, George C. Fresh-Water Biology, John Wiley and Sons, Inc., New York, New York, 1959.

13. Wilhm, Jerry L. and Dorris, Troy C. "Biological Parameters for Water Quality Criteria," BioScience 18(6), 1968.

In addition, the Hach Chemical Company will provide, upon request, an educational brochure and explanation of Hach water chemistry at no charge. These can be ordered at the following address: Hach Chemical Company, P.O. Box 907, Ames, IA 50010.

INFORMATION FOR PURCHASING WATER ANALYSIS KITS

Iowa-ASSIST (USE) can provide schools the five water test kits at a substantial saving ($10.50) to individual schools. The test kits used in the Local Ecology Project are as follows:

Dissolved Oxygen (Model OX-2P)

Features
Readout: 1 drop = 1 mg/l as dissolved oxygen
Method of Analysis: Titrimetric, drop count titration
No. of Average Tests: 100
Case: 7½ x 5 x 5 inches, black styrene plastic
Shipping Weight: 3 lbs
Order Cat. No. 1469-00 . . . . . 17.00

Alkalinity (Model AL-AP)

Features
Readout: 1 drop = 0.4 gpg or 1 gpg alkalinity as calcium carbonate
Method of Analysis: Titrimetric, drop count titration
No. of Average Tests: 50
Order Cat. No. 1433-00 . . . . . 8.50

Nitrate

Features
Method of Analysis: Colorimetric, using test cube
No. of Tests per Kit: 50
Case: 3 3/4 x 2 7/8 x 1 3/8 inches, black plastic
Shipping Weight: 6 oz
Order Cat. No. 14037-00. . . . . 5.00

Phosphate

Features
Method of Analysis: Colorimetric, using test cube
No. of Tests per Kit: 50
Case: 3 3/4 x 2 7/8 x 1 3/8 inches, black plastic
Shipping Weight: 6 oz
Order Cat. No. 12522-00. . . . . 5.00

Ammonia Nitrogen

Features
Method of Analysis: Colorimetric, using test cube
No. of Tests per Kit: 100
Case: 3 3/4 x 2 7/8 x 1 3/8 inches, black plastic
Shipping Weight: 6 oz
Order Cat. No. 12524-00. . . . . 5.00

*Note all (5) of the above kits can be purchased for a total of $40.00.

Purchase Orders should be made out to:

Iowa-USE
356 Physics Building
University of Iowa
Iowa City, IA 52242

DATA REPORT FORM

School:_____ Reporter(s):_____

Computer Data

School District Number (obtain from administration):_____

Area Education Agency Number:_____

School District Name:_____

Sampling Date:_____ Time:_____ A.M. P.M. (Circle)

Water System (i.e. Iowa River, Clear Lake, Jone's Gravel Pit):

_____

Sampling Site Number:_____

Location:_____-_____
(County Name) (Township Name)

_____-_____-_____-_____
Township No. Range No. Section No. Quarter

I. Chemical Parameters
1. Alkalinity. . . . . ._____ppm
2. Dissolved Oxygen (surface). . . . ._____ppm
3. Dissolved Oxygen (benthic). . . . ._____ppm
4. Ammonium (surface). . . . . ._____ppm
5. Nitrate (NO_3) (surface) . . . . . ._____ppm
6. Phosphate (PO_4) (surface) . . . . ._____ppm

II. Physical Parameters
7. Temperature (air) . . . . . ._____^oC
8. Temperature (water-surface) . . . ._____^oC
9. Temperature (water-benthic) . . . ._____^oC
10. Transparency (Secchi disc). . . . ._____cm.
11. Velocity. . . . . ._____m/sec.
12. Depth . . . . . ._____cm.
13. Flow level (check one). . . . . ._____Flood
_____Bank Full
_____Average
_____Low
_____Very Low

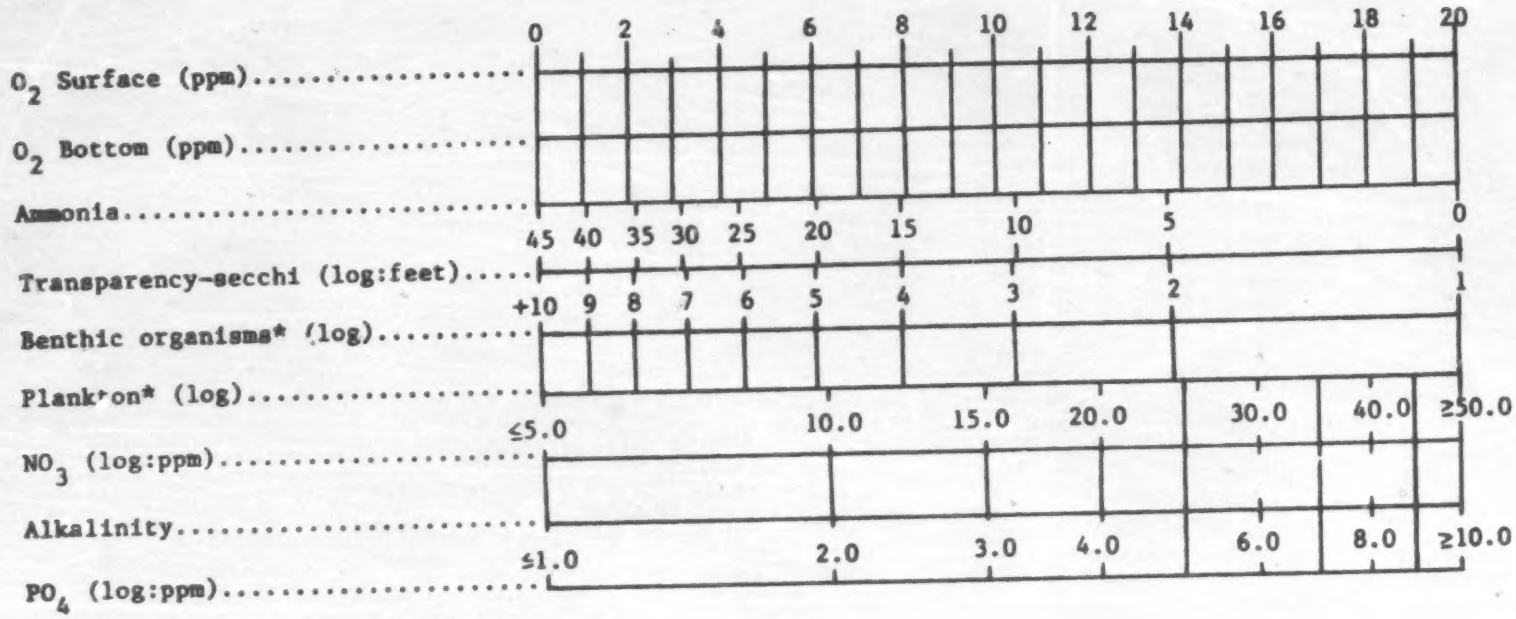
III. Biological Parameters
14. Diversity Index (benthic) . . . . ._____
15. Diversity Index (plankton). . . . ._____

* *

Descriptive Narrative of Sample Site:

ENVIRONMENTAL PROFILE:

(Modified from Kaill & Frey, 1973)


O_2 Surface (ppm)
0 2 4 6 8 10 12 14 16 18 20
O_2 Bottom (ppm)
Ammonia
45 40 35 30 25 20 15 10 5 0
Transparency-secchi (log:feet)
+10 9 8 7 6 5 4 3 2 1
Benthic organisms* (log)
Plankton* (log)
≤5.0 10.0 15.0 20.0 30.0 40.0 ≥50.0
NO_3 (log:ppm)
Alkalinity
≤1.0 2.0 3.0 4.0 6.0 8.0 ≥10.0
PO_4 (log:ppm)

*Diversity Index = $\frac{N^2}{\sum(n)^2}$

Date_____

Site Number_____

Location_____

_____

Values of environmental conditions increase from left to right, with the exception of secchi transparency, and the diversity indices, which increases from right to left. Generally, steril environments will register toward the left end of the diagram (Oligatrophic Environment). Richer environments will register toward the right end of the diagram. As the profile moves to the right, the range of values for a given factor (width of profile) should increase. Also, the profiles may become jagged in appearance. A "spike," or a particular factor that departs radically from the other values of the column is worth investigation (Eutrophic Environment). A profile can be assembled from data over a period of time, so that departures from the assembled profile, representing environmental shifts, may be determined and investigated.